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WETTING AGENT FAILS TO CURB EROSION
from burned watershed

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ABSTRACT: Wetting agents are being tried as a means of inducing wettability in water repellent soils so as to reduce surface runoff and erosion. Two burned drainages in the hills above Glendora, in southern California, were used in a watershed-scale test. One drainage was sprayed with a wetting agent; the other served as untreated control. The treated watershed had about 16 percent more erosion than the control. Studies are underway to find out why the wetting agent treatment failed, and to develop more effective techniques.

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RETRIEVAL TERMS: post-fire erosion control; wetting agents; Emery 3685; surfactants.

Water repellent soils have been found in numerous places throughout California and the Western United States.[1] Brush or timber fires can greatly intensify existing water repellency. In an unburned condition the water repellent layer is usually found at the soil surface. This layer slows water infiltration, but because the water detained by the repellent layer can be stored temporarily in the litter on the soil surface, excessive runoff rarely results. A fire destroys the litter and the water repellency of the top few inches of soil, but a new, much more intense water repellent barrier is created in the soil 1 to 3 inches below the surface.[2]

A soil in this condition presents serious hydrologic problems. The intense heat of a fire reduces the surface layer to an extremely erodible powder. The presence of a water repellent barrier immediately below the surface means that only a thin layer is available to store and transmit water in a rainstorm. Consequently, even in relatively small showers, the layer quickly becomes saturated, producing excessive surface runoff and erosion.

Since 1963 we have been testing wetting agents in the laboratory and on small plots to reduce post-fire runoff and erosion.[3] Over the years our plots have shown an average reduction of about 40 percent in runoff and about a 35 percent reduction in erosion. By spring 1968 it seemed likely that the wetting agent treatment could be used successfully to rehabilitate burned watersheds. We decided to undertake a watershed-scale test of the wetting agent should the fire season provide an opportunity—even though there were still many unexplored facets of the problem presented by water repellent soils and the use of wetting agents. By so doing, we hoped that an effective, if not optimal, watershed rehabilitation treatment could soon be offered to land managers.

PILOT TEST

Two fires in 1968—the Easley fire of July 12 and the Canyon fire of August 23—on the hills behind

Glendora, northeast of Los Angeles, California, provided the opportunity for a pilot test. Two adjacent drainages–Harrow and Englewild Canyons–had debris basins at their mouths and were similar in size, slope, aspect, elevation, soil, intensity of burn, and physiography. The management agencies concerned–the Los Angeles County Flood Control District, the Los Angeles County Fire Department and the Angeles National Forest–pooled their resources to purchase the wetting agent and rent a helicopter to apply it. The California Division of Forestry helped in fabricating and installing runoff plots in the treated watershed (Englewild Canyon) and in the control watershed (Harrow Canyon). A total of 20 plots and 15 raingages were installed *(fig. 1)*. Each installation consisted of a pair of .01-acre plots, an anemometer to record wind travel near the soil surface, a raingage, a collector trough to measure erosion, a tipping bucket to record runoff, and a water quality sampling bottle. To the extent possible, the plots were distributed within the watersheds to provide an adequate representation of their various slopes and aspects.

THE TREATMENT

The wetting agent Emery 3685[4] was applied to Englewild Canyon on November 19. By keeping the drums of wetting agent heated to 100°F. it was possible to apply it undiluted. The helicopter flew over the canyon twice, using 26 D-8 nozzles at 25 psi pressure during the earlier passes, and 38 nozzles later when it was observed that the chemical was not being used rapidly enough. The rate of application was 6-2/3 gallons per *surface* acre. This rate of application was used in all earlier plot studies. Lacking any way of accurately appraising the needs of a particular soil, we felt that it was desirable to use a rate which would permit us to compare, in a rough way, the performance of the plots in this study with previous plot experiments. Blotters installed at each plot site indicated that the wetting agent had been distributed uniformly over the watershed.

We computed costs on the basis of *surface* acreage because in steep terrain, such as the Englewild watershed, the use of map acreages can lead to an appreciable underestimate of the area of soil requiring treatment. The treated watershed measured 274 map acres. However, since the average slope was 55 percent and one-third of the watershed exceeded 80 percent slope, the surface area was 315 acres.

The cost of treatment was $21 per *surface* acre. Since the cost of applying the chemical represents about one-fifth to one-fourth of the treatment cost we welcomed the discovery that it was possible to apply it in a pure form.

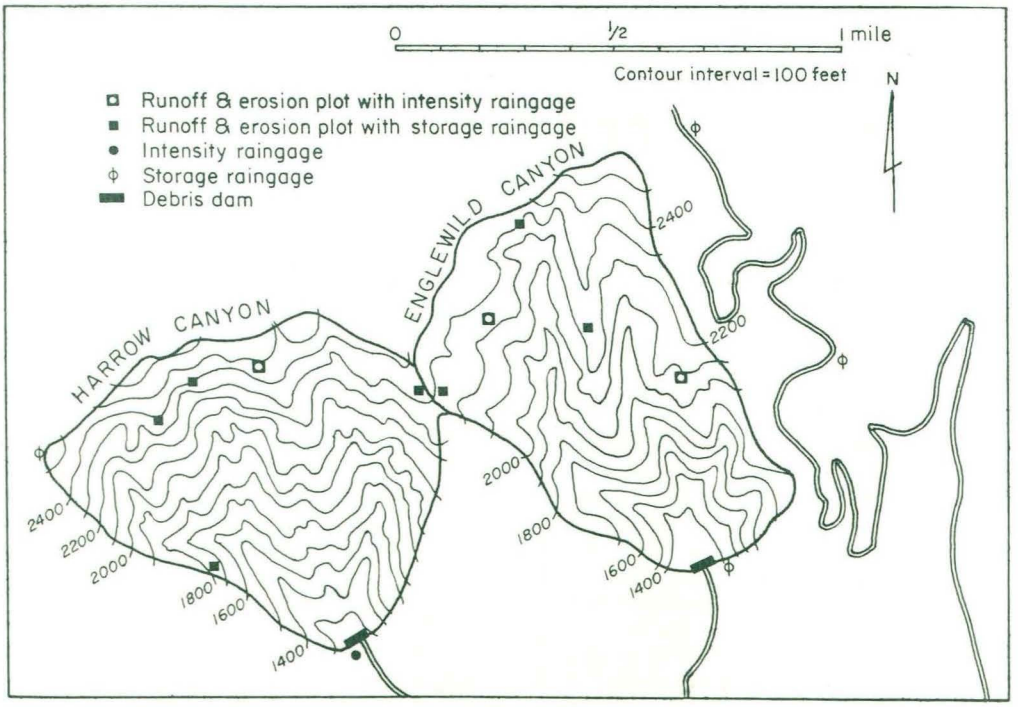

Figure 1–*The two adjacent drainages used in the pilot test of wetting agent treatment are on the hills north of Glendora, California.*

problems can be solved, action programs which might help reduce flood damages can be begun. A lasting solution of the problem of water repellent soils, however, will have to await answers to the questions which we have raised about wetting agents and water repellent soils.

NOTES

[1]DeBano, Leonard F. *Observations on water repellent soils in western United States. In,* Proc. Symp. on Water-Repellent Soils. Univ. Calif., Riverside, 1968: 17-29. 1969.

[2]DeBano, L. F. *Formation of non-wettable soils...involves heat transfer mechanism.* U.S. Forest Serv. Res. Note PSW-132, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 8 p. 1966.

[3]Krammes, Jay S.,and Osborn, Joseph. *Water repellent soils and wetting agents as factors influencing erosion. In,* Proc. Symp. on Water-Repellent Soils, Univ. Calif., Riverside, 1968: 177-187. 1969.

[4]Manufactured by Emery Industries, Inc., Sante Fe Springs, Calif. Trade names and commercial products or enterprises are mentioned solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

[5]Valoras, N.,and Letey, J. *Quantitative analysis for nonionic surfactants in soil leachates.* Proc. Soil Sci. Soc. Amer. 32: 737-739. 1969.

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The debris production of the treated watershed was twice that in the control. Since only three of the 20 erosion troughs caught measurable erosion, however, this discrepancy did not cause us much concern. On the other hand, the control area had almost twice as much runoff as did the treated area, and all of the plots which failed to produce runoff were in the treated area. This pattern was preserved during the storm of January 13-14.

Possible water pollution had been one of our concerns. These first two storms tended to allay our fears. In neither of them did the runoff from the plots or in the streams show measurable amounts of wetting agents. If wetting agent was being released into the streamflow, it was in concentrations less than the sensitivity (5 ppm) of the analytical procedure developed by Valoras and Letey.[5]

Finally, almost 2 months to the day after it was applied, the first real test of the wetting agent occurred: the disastrous storm and floods of January 1969. Our runoff recorders were not up to the task, and consequently we have no information concerning any possible treatment effect on overland flow. Long before the storm had become a record breaker, it was obvious that the wetting agent was not doing its job. The water repellent barrier was very much in evidence in both Harrow and Englewild Canyons. During a break in the storm on January 23 the erosion troughs were emptied, revealing nearly equal erosion in the treated and control watersheds. During the second phase of the storm the control plots eroded at a lower rate than the treated plots so that when the rain had quit on January 26 the treated plots had produced about 16 percent more erosion than the control plots.

DISCUSSION

In trying to determine why the wetting agent treatment failed, we can consider at least three possibilities: (1) The soil may be different than any we have previously dealt with. (2) This is the first time that we had applied the chemical undiluted. (3) This was the first time that the chemical was required to lie on the soil surface for such a long period of time before being soaked in by rainfall. These differences from what we had previously experimented suggest some possible explanations:

- The substance causing the water repellent condition was in some manner recoating the surfaces which had become wettable by the wetting agent.
- The wetting agent evaporated from the surface.
- The loss of soil moisture after the wetting agent was applied may reduce its ability to induce wetting in the soil when rain fell.
- The sun, shining on the black soil surface, created high soil temperatures. The high temperatures caused the wetting agent molecules, lying on the wettable soil surface, to reorient, binding the hydrophilic portions to the hydrophilic soil. This orientation of the wetting agent molecules would expose the hydrophobic portion of the molecules to infiltrating water, thereby recreating a water repellent layer.
- Heat or sunlight caused a chemical breakdown of the wetting agent.
- The wetting agent may have undergone microbial decomposition.
- The adsorption capacity of the surface soil may have been great enough that all of the wetting agent molecules were captured in the wettable surface soil before reaching the water repellent layer.
- The soils on the study area were inherently extremely water repellent, and not enough wetting agent was applied to promote infiltration.

THE PRESENT OUTLOOK

We are now studying these possibilities and already have some clues about their validity. We are reasonably sure that at least part of the explanation lies in the last alternative—the extreme water repellency of the soils of Englewild Canyon. In some respects it would be encouraging if the water repellency of the Englewild Canyon soils caused the treatments to fail. There would be rather formidable operational problems if wetting agents—to be successful—had to be applied immediately before a rainstorm. As yet we cannot satisfactorily predict the quantity of wetting agent necessary to affect penetration of a particular soil. Even further removed from our present capabilities is a method of measuring quantitatively the amount of water repellent substances in a soil.

While there remains a formidable list of unsolved problems, the outlook is fairly optimistic. The discovery of water repellent soils has placed us on the trail of one of the important causes of accelerated post-fire runoff and erosion. In research, asking the correct question is often half the battle. We are confident that we are on the right track.

In the meantime we have two immediate high priority goals: First, we must develop an empirical appraisal for the quantity of wetting agent needed in a particular situation; and second, we must develop a satisfactory method of application. If these two

This was our first use of the undiluted chemical. In an earlier test, the wetting agent had been applied either in a granular form (58 percent active ingredient) or diluted by at least one-third water and isopropyl alcohol. We found no differences in effectiveness related to mode of application. Applying the treatment in granular form would have increased the cost by 60 percent which would have nearly eliminated the expected benefits. Dilution with water and alcohol would have increased the over-all costs mainly by requiring more flying time.

THE RESULTS

On November 26, strong dry north winds struck the study area. Owing to the lay of the land, the treated watershed was hit harder than the control watershed. We were concerned that the wetting agent may have been blown from the watershed surface. On the following morning, we took soil samples from exposed and sheltered spots within the treated and control watersheds, and collected dust from gutters in the streets of Glendora immediately below the treated watershed. These samples were analyzed for the presence of wetting agent. We found that, indeed, the wetting agent had been removed from the most exposed ridge sites. However, only a short distance off the ridge, the treatment was still intact. No wetting agent was found in the control watershed nor in the samples taken from the streets.

Rainfall before the application of the wetting agent totaled 1.32 inches. Thereafter only small showers fell until Christmas Day *(table 1)*.

Table 1 –*Rainfall and post-fire erosion from two adjacent watersheds, Glendora, California*

Dates (1968-69)	Rainfall[1]	Harrow Canyon (control watershed)		Englewild Canyon (treated watershed)[2]	
		Erosion	Total to date	Erosion	Total to date
	Inches	*yd.*^{3}*/ac.*			
12/11	0.09				
12/15-12/16	.18				
12/20	.10				
12/25-12/26	.92				
11/27-12/27	–	0.18	0.18	0.33	0.33
01/13-01/14	1.70				
12/27-01/16	–	.10	.28	.48	.81
01/18-01/22	9.19				
01/16-01/22	–	26.04	26.32	25.58	26.39
01/23-01/26	11.02				
01/28	.41				
01/22-01/28	–	9.07	35.39	14.75	41.11
02/05-02/06	2.80				
01/28-02/10		10.30	45.69	7.49	48.60
02/15	1.04				
02/17-02/20	1.48				
02/21-02/22	.70				
02/23-02/25	7.76				
02/10-02/26	–	3.74	49.43	6.60	55.20
02/28	.85				
03/09-03/10	.68				
03/12	.05				
03/21	.84				
02/26-03/24	–	.38	49.81	.30	55.50
04/02-04/03	.60				
04/05	.43				
04/09-04/10	.15				
05/03-05/06	.17				
03/24-05/09	–	.04	49.85	.04	55.54

[1]Recorded at Harrow Dam.
[2]Sprayed with wetting agent.

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